

have been responsible for the presence of the species in Tampa Bay.

To judge from the numbers of threadfin shad seen in 1965, the species has become firmly established in Old Tampa Bay. In California, transplants of threadfin shad in the Colorado River during 1954 resulted in a population eruption at the end of 1955 in every habitable part of the Colorado River drainage system (Kimsey, 1957; Shapovalov, Dill, and Cordone, 1959). If threadfin shad become plentiful in Old Tampa Bay, they may be kept under control by such predators as snook, *Centropomus undecimalis*, sand seatrout, *Cynoscion arenarius*, spotted seatrout, *C. nebulosus*, and silver perch, *Bairdiella chrysura*. Additional ecological studies are needed to determine fully the effects of the threadfin shad on the resident biota.

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FOSSIL BIRDS FROM THE DOMINICAN REPUBLIC

LOWELL BERNSTEIN

No work has yet been published on the fossil avifauna of the Dominican Republic, although Wetmore (1922b) reported four species from Haiti in the western half of the island of Hispaniola. Under the joint auspices of the Universidad de Santo Domingo, the Museum of Comparative Zoology at Harvard College, and a Sigma Xi-RESA grant-in-aid, a field party comprising Professor Eugenio Jesús Marcano F., Clayton E. Ray, and A. Stanley Rand collected numerous vertebrate remains from a cave in the Dominican Republic, during the period Aug. 7-Sept. 2, 1958.

The cave lies at an altitude above 2000 feet near the top of Cerro de San Francisco, an isolated limestone hill in the Municipio Pedro Santana, Provincia San Rafael, near the Haitian border. Its floor is very dry and is covered with roof debris, goat dung, and owl pellets. A pit dug near the back wall of the cave disclosed three bone-bearing strata:

Stratum 1. Surface to 15 inches, containing remains of *Rattus* and goat. Post-Columbian.

Stratum 2. A charred black layer, 6-12 inches thick, containing human bones and traces of cooking fires, but no *Rattus* or goat remains. Also present were frogs, lizards, birds, bats, and the extinct mammals *Nesophontes*, *Isolobodon*, and *Brotomys*. Because of the absence of domestic animals and the evidence of aboriginal occupancy, stratum 2 is thought to be pre-Columbian, but not older than 2000 B.C.

Stratum 3. A light brown layer, 3-4 feet thick, containing remains of lizards, birds, bats, sloth, *Isolobodon*, *Brotomys*, *Plagiodontia*, and *Nesophontes*, but without evidence of human occupancy or domestic animals. It is thought to be of late Pleistocene age.

Etheridge (1965) has reported on the fossil lizards from Cerro de San Francisco, including an extinct species of *Leiocephalus*. The birds from strata 2 and 3 form the basis of the present report. The avifauna is the largest yet recovered from a West Indian fossil locality, with 42 species identified. The deposit is also rich in individual specimens. From stratum 2 representatives of 26 species of birds were identified from 224 bones. From stratum 3 no less than 539 bones were identified, representing 32 species. The material is deposited in the Florida State Museum.

Myological and osteological terminology follows that of Hamon (1964).

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Family RALLIDAE

1. *Porzana carolina* (Linnaeus)

Stratum 2: proximal portions of 2 right humeri. Stratum 3: proximal portion of right humerus, proximal portion of right femur.

This is the first Caribbean fossil record of the sora rail.

2. *Porzana flaviventer* (Boddaert)

Stratum 3: 7 specimens of humerus and femur, representing a minimum of 3 individuals.

Wetmore (1922a) identified the yellow-breasted crake from a cave deposit in Puerto Rico.

3. *Porphyryla martinica* (Linnaeus)

Stratum 3: 5 specimens of sternum, femur, and tarsometatarsus, representing at least 2 individuals.

Wetmore (1952) identified the purple gallinule from a shell-midden on Martinique.

Family COLUMBIDAE

4. *Columba leucocephala* Linnaeus

Stratum 2: distal portion of right tarsometatarsus, complete left tarsometatarsus. Stratum 3: proximal portion of left femur, complete left tarsometatarsus.

Wetmore (1922a, 1937a, 1938) reported the white-crowned pigeon from cave deposits on Puerto Rico, St. Croix, and Crooked

Island. Brodkorb (1959) reported it from a Pleistocene locality on New Providence.

The femur of *C. leucocephala* is smaller than that of *C. squamosa* and *C. inornata*. Its tarsometatarsus has a narrower posterior metatarsal groove, and the attachment for the external ligament is rotated forward.

5. *Columba squamosa* Bonnaterre

Stratum 2: 6 specimens of ulna and femur, representing at least 3 individuals. Stratum 3: distal portion of right humerus.

Wetmore (1922a, 1937a, 1937b, 1938, 1952) identified the red-necked pigeon from cave deposits in Puerto Rico, St. Croix, and Great Exuma Island, and from middens on Puerto Rico and Martinique. Brodkorb (1959) identified it from the Pleistocene of New Providence.

C. squamosa and *C. inornata* are quite similar in size and shape. A high degree of individual variation was noted, and many specimens were unidentifiable to species. However, in the humerus *C. squamosa* has the attachment for the anterior articular ligament and the ectepicondylar process better developed, and the ectepicondylar process is more palmar, with a small but well-developed ridge just below it. The ulna of *C. squamosa* has a prominent ridge over the bicipital attachment, absent in *C. inornata*. In the femur the attachments for the external head of *M. gastrocnemius* and *M. adductor profundus* are better developed in *C. squamosa* than in *C. inornata*.

C. squamosa is more common on the island today than *C. inornata* (Wetmore and Swales, 1931).

6. *Zenaidura macroura* (Linnaeus)

Stratum 2: left radius, right tarsometatarsus.

This is the first Caribbean fossil record of the mourning dove.

7. *Zenaida aurita* (Temminck)

Stratum 2: 5 specimens of humerus, ulna, and synsacrum, from a minimum of 3 individuals.

Wetmore (1922a, 1937, 1938, 1952) reported the zenaida dove from cave deposits or middens on Puerto Rico, St. Croix, and Mar-

tinique. Brodkorb (1959) identified it from the Pleistocene of New Providence island.

8. *Zenaida asiatica* (Linnaeus)

Stratum 2: 5 specimens of humerus, ulna, and synsacrum, representing 3 individuals. Stratum 3: 4 specimens of sternum, humerus, and tarsometatarsus, representing at least 2 individuals.

This is the first fossil record of the white-winged dove.

Compared with *Z. aurita*, the humerus is larger and has a heavier shaft. The ulna has a heavier shaft and a deeper proximal brachial depression. The sternum has a larger pneumatic foramen than in *Z. aurita*.

9. *Geotrygon* sp. indet.

Stratum 2: 11 specimens of humerus and femur, representing 7 individuals. Stratum 3: 6 specimens of coracoid, carpometacarpus, and tibiotarsus, from at least 2 individuals.

These specimens are too large for *G. montana*, but no skeletons of *G. caniceps* or *G. chrysis* were available for comparison.

10. *Columbigallina passerina* (Linnaeus)

Stratum 2: 59 specimens of humerus, ulna, synsacrum, femur, tibiotarsus, and tarsometatarsus; 23 individuals. Stratum 3: 235 specimens of sternum, coracoid, humerus, ulna, carpometacarpus, femur, tibiotarsus, and tarsometatarsus; 26 individuals.

Wetmore (1922a) identified the ground dove from cave deposits in Haiti. The fossils from the older layer, stratum 3, are smaller than those from stratum 2. Thirteen humeri from stratum 3 have a length of 18.8-20.1 mm (mean 18.6). From stratum 2 the length of 32 humeri is 19.3-21.3 (mean 19.9).

Family CUCULIDAE

11. *Coccyzus* sp. indet.

Stratum 2: proximal portion of right humerus, complete left femur.

The humerus has the bicipital furrow too deep for *C. erythrophthalmus*. The border between the external tuberosity and the head is almost straight, as in one of two specimens of *C. minor*, but the capital groove ridge is developed as in *C. americanus*.

The femur has a prominent posterior intermuscular line as in *C. erythroptalmus*, but there is an indentation of the shaft above the fibular condyle as in *C. americanus* and *C. minor*. Additionally, the distal end of the shaft is triangular in cross-section, unlike that in the other species of *Coccyzus*.

12. *Coccyzus erythroptalmus* (Wilson)

Stratum 2: Distal portion of a left humerus.

This is the first fossil record of the black-billed cuckoo.

The humerus of *C. erythroptalmus* has the smallest entepicondylar prominence and the most lateral scar for *M. pronator longus*. The distal width is: fossil, 5.7; *C. erythroptalmus* (5), 5.3-6.0; *C. americanus* (19), 5.5-6.5; *C. minor* (2), 6.0-6.1 mm.

13. *Hyetornis rufigularis* (Hartlaub)

Stratum 2: shaft of left humerus. Stratum 3: 6 specimens of sternum, humerus, tibiotarsus, and tarsometatarsus.

The bones are those of a very large cuckoo, but can only be assigned tentatively in the absence of comparative material.

14. *Saurothera longirostris* (Hermann)

Stratum 2: 12 specimens of humerus and ulna, from 5 individuals. Stratum 3: 13 specimens of coracoid, humerus, and carpo-metacarpus, from 5 individuals.

The coracoid is too large for *Coccyzus*, and the brachial tuberosity is too pointed for *Crotophaga*.

The humerus has a deep, circular bicipital furrow, which is shallower in *Coccyzus* and becomes very shallow and oval in *Crotophaga*. The bicipital crest in the fossils is long, as in *Crotophaga*, but its edge is flatter and the internal tuberosity larger and deflected at a greater angle to the shaft than in *Crotophaga*. A very noticeable groove marks the distal border of the bicipital surface. The attachment for the anterior articular ligament is shorter and less elevated than in most specimens of *Crotophaga*, and the distal width of the bone is generally less.

The length of the humerus is: fossil (4), 32.8-34.1; *Crotophaga ani* (4), 34.1-38.3; *Coccyzus americanus* (17), 28.8-31.5 mm.

The ulna is slightly shorter but heavier than in *C. americanus*.

The carpometacarpus has a deeper depression above the pisiform process than in *Coccyzus*.

I have assigned the fossils to *S. longirostris* in the absence of comparative material of this species, as they are within its size range and are neither *Coccyzus* nor *Crotophaga*.

15. *Crotophaga ani* Linnaeus

Stratum 2: 12 specimens of humerus, femur, tibiotarsus, and tarsometatarsus; at least 3 individuals.

Wetmore (1922a) identified the smooth-billed ani from a cave deposit in Haiti.

Family TYTONIDAE

16. *Tyto alba* (Scopoli)

Stratum 2: 21 specimens of scapula, coracoid, humerus, carpometacarpus, femur, tibiotarsus, and tarsometatarsus; at least 4 individuals.

Brodkorb (1959) identified the barn owl from the Pleistocene of New Providence.

Many of the bones are immature and indicate that the barn owl nested in the cave at the time of deposition.

Family STRIGIDAE

17. *Speotyto cunicularia* (Molina)

Stratum 2: right ulna, distal portion of right tarsometatarsus.

Wetmore (1937b) reported the burrowing owl from a cave deposit on Great Exuma island.

18. *Asio* sp. indet.

Stratum 2: 9 specimens of humerus and femur, from 7 individuals. Stratum 3: distal portion of right tarsometatarsus.

The only mature specimens are 2 distal portions of right humeri. These have width of 12.5-13.4 mm, compared with 13.5-14.5 in *Asio flammeus* and 14.8-16.5 in *Tyto alba*. The ectepicondylar process is lateral, as in *A. flammeus*, but the distal end of the shaft is more reflected than in that species or *Tyto*. It is possible that these specimens represent the rare *Asio stygius* Wagler, no skeletons of which were available.

Family CAPRIMULGIDAE

19. *Siphonorhis brewsteri* (Chapman)

Stratum 2: proximal portion of a right ulna. Stratum 3: 19 specimens of sternum, humerus, carpometacarpus, tibiotarsus, and tarsometatarsus.

S. brewsteri is the smallest caprimulgid on the island, but no skeletal material was available for comparison. Wetmore and Swales (1931) note that it has a very long tarsometatarsus, and both they and Bond (1940) state that it is closely related to the mainland *Nyctidromus*. The sternum resembles that of *Nyctidromus albicollis* in that the manubrium is very smooth and without dorsal and ventral manubrial spines, but differs in lacking the large foramen ventral to the manubrium.

Family TROCHILIDAE

20. *Anthracothonax dominicus* (Linnaeus)

Stratum 3: synsacrum.

This is the first fossil record of the Antillean mango hummingbird and the first fossil record for the family that could be identified to species.

The synsacral length of the fossil is 11.2; a recent skeleton, 10.6; *Chlorostilbon swainsonii*, 9.2 mm. *A. dominicus* has two pairs of large parapophyses in the thoracic region and three large and one small pair in the caudal region, whereas *C. swainsonii* has a single pair of thoracic parapophyses and four large pairs in the caudal region.

The tiny *Mellisuga minima* and *Archilochus colubris* are the only other hummers on the island. They are both much smaller, and *Archilochus* has three pairs of caudal parapophyses and a prominent bulge on the dorsal surface.

Family TROGONIDAE

21. *Temnotrogon roseigaster* (Vieillot)

Stratum 3: 5 specimens of mandible, coracoid, humerus, and ulna.

This is the first fossil record of the Hispaniolan trogon.

Family TODIDAE

22. *Todus angustirostris* Lafresnaye

Stratum 3: 4 specimens of coracoid, humerus, and tibiotarsus.

This is the first fossil record of the narrow-billed tody and for the family Todidae.

T. angustirostris is slightly smaller than *T. subulatus*. The brachial tuberosity of the coracoid is hooked in *T. angustirostris*, rounded in *T. subulatus*. The pneumatic fossa of the humerus has a single large fenestra with strutwork in *T. angustirostris*, but in *T. subulatus* there are only a few small fenestrae, without struts. The condyles of the tibiotarsus have a distinct heel in *T. subulatus*, and the shaft is flattened into a blade where it joins the posterior intercondylar sulcus. A fossil ulna could not be identified to species.

23. *Todus subulatus* Gray

Stratum 3: complete left femur.

This is the first fossil record of the broad-billed tody.

The neck of the femur is almost straight below the head in *T. subulatus*, rounded in *T. angustirostris*. The distal third of the shaft is straight in *T. subulatus*, bent posteriorly in *T. angustirostris*. The rotular groove is less concave in *T. subulatus*.

Family PICIDAE

24. *Nesocittes micromegas* (Sundevall)

Stratum 2: left humerus, left tarsometatarsus. Stratum 3: 9 specimens of coracoid and humerus; minimum 4 individuals.

Identification of the Antillean piculet, the smallest woodpecker on Hispaniola, was on size, as no skeleton was available.

25. *Melanerpes striatus* (Müller)

Stratum 2: 13 specimens of skull, humerus, ulna, femur, tibiotarsus and tarsometatarsus. Stratum 3: 11 specimens of sternum, coracoid, humerus, carpometacarpus, tibiotarsus, and tarsometatarsus.

This is the first fossil record of the Hispaniolan woodpecker.

26. Picidae, gen. et sp. indet.

Stratum 3: left tibiotarsus.

The specimen is nearly complete except for damage to the con-

dyles and cnemial crest. It is smaller than *M. striatus* and larger than *Sphyrapicus varius*. It differs in lacking a shelf external to the peroneus brevis groove and in having a blade-like, rather than knob-shaped, attachment for the oblique ligament, similar to that found in *M. carolinus*. It may represent an undescribed species.

Family TYRANNIDAE

27. *Tyrannus dominicensis* (Gmelin)

Stratum 2: proximal portion of left humerus, complete right humerus. Stratum 3: Proximal portions of a right and a left humerus.

Wetmore (1922a) identified the gray kingbird from cave deposits in Puerto Rico.

28. *Tolmarchus caudifasciatus* (d'Orbigny)

Stratum 2: a right and 2 left humeri.

Wetmore (1922a, 1922b) reported the loggerhead flycatcher from caves in Puerto Rico and Haiti.

29. *Contopus* sp. indet.

Stratum 2: left humerus. Stratum 3: left coracoid.

The humerus closely resembles that of *C. virens*, but no skeleton of *C. caribaeus* was available for comparison.

Family HIRUNDINIDAE

30. *Petrochelidon fulva* (Vieillot)

Stratum 2: left humerus. Stratum 3: 3 left humeri.

Wetmore (1922a) reported the cave swallow from cave deposits in Puerto Rico.

The humerus of this species has a heavier shaft and a larger accessory process on the ectepicondylar prominence than in *Lamprochelidon euchrysea*. The scar for *M. coracobrachialis posterior* is longer and the capital groove is shallower near the shaft than in *Hirundo rustica*.

Family MIMIDAE

31. *Mimus polyglottos* (Linnaeus)

Stratum 2: 2 right humeri, left tibiotarsus.

Wetmore (1922a) identified the mockingbird from cave deposits

in Puerto Rico. He noted that they were smaller than mainland specimens, and this is also the case for the Dominican fossils.

Family TURDIDAE

32. *Mimocichla plumbea* (Linnaeus)

Stratum 2: 18 specimens of humerus, ulna, and carpometacarpus; 8 individuals. Stratum 3: 5 specimens of coracoid and humerus; 2 individuals.

The red-legged thrush was reported by Wetmore (1922a, 1937b) from cave deposits on Puerto Rico and Great Exuma.

Family DULIDAE

33. *Dulus dominicus* (Linnaeus)

Stratum 2: proximal portion of left humerus, complete left humerus. Stratum 3: proximal portion of right humerus, left tarsometatarsus.

This is the first fossil record of the palm chat and its monotypic family.

Family VIREONIDAE

34. *Vireo altiloquus* (Vieillot)

Stratum 2: right and left humerus. Stratum 3: 5 humeri; 4 individuals. This is the first fossil record of the black-whiskered vireo.

35. *Lawrencina nana* (Lawrence)

Stratum 3: right humerus, right tarsometatarsus.

The flat-billed vireo is the smallest vireo on the island. Although a skeleton was not available, the fossil humerus is small, and the tarsometatarsus is long and slender, as noted by Wetmore and Swales (1931).

Family PARULIDAE

36. *Dendroica* sp. indet.

Stratum 3: 2 mandibles.

It appears impossible to identify these fossils to species.

37. *Sciurus aurocapillus* (Linnaeus)

Stratum 3: 2 rostra.

This is the first fossil record of the ovenbird.

The rostrum of *S. noveboracensis* is smaller and narrower, of *S. motacilla* broader and shorter. The rostra of *Microligea palustris* and *M. montana* are quite similar to that of *S. aurocapillus*, but they have a nasal partition, lacking in the ovenbird.

38. Parulidae, gen. et sp. indet.

Stratum 3: anterior portion of a rostrum.

This specimen is closest in size and shape to *Limnothlypis swainsonii*, but differs in having the anterior border of the nostril slope inward. The nasal process of the maxillary is heavier. The depression in the palate is square, channel-shaped rather than rounded, with a slight central double ridge.

Family THRAUPIDAE

39. *Loxigilla violacea* (Linnaeus)

Stratum 2: 34 rostra and mandibles; 18 individuals. Stratum 3: 23 specimens of rostrum, mandible, and tarsometatarsus; 14 individuals.

This is the first fossil record of the Greater Antillean bullfinch.

40. *Phaenicophilus palmarum* (Linnaeus)

Stratum 2: 34 specimens of rostrum, mandible, and humerus; 18 individuals. Stratum 3: 34 specimens of rostrum, mandible, and humerus; 10 individuals.

This is the first fossil record of the black-crowned palm tanager.

The humeri from stratum 3 are shorter than those from the younger stratum 2. The length of 9 humeri from stratum 3 is 18.7-20.3 (mean 19.6); of 26 humeri from stratum 2 it is 19.7-21.1 (mean 20.4 mm).

41. *Calyptophilus frugivorus* (Cory)

Stratum 2: 6 specimens of tibiotarsus and tarsometatarsus; 2 individuals. Stratum 3: 3 right and 1 left femora.

Although modern material was not available, *C. frugivorus* is the only unavailable higher passerine to which the fossils might

belong. Compared with *Phaenicophilus*, the femora are larger and heavier, with the scar of M. adductor profundus better developed. The 2 tibiotarsi are thicker and have lengths of 31.6 and 32.6 mm.

Family FRINGILLIDAE

42. *Tiaris bicolor* (Linnaeus)

Stratum 2: 1 rostrum. Stratum 3: 91 rostra and mandibles; 49 individuals.

This is the first fossil record of the black-faced grassquit.

Compared with *Tiaris bicolor*, the rostrum of *T. olivacea* is very narrow, with the sides concave, and with a distinct bulge just anterior to the juncture of the nasal and maxillary. Mandibles of the two species are not distinguishable, but are included here in the absence of rostra of *T. olivacea*.

43. *Brachospiza capensis* (Müller)

Stratum 3: 15 specimens of rostrum, mandible, and left tarsometatarsus.

This is the first fossil record of the Andean sparrow.

The tarsometatarsus compares well with Central American skeletons of this species and has a similar shallow facet for metatarsal one. It is, however, slightly shorter than the measurements of the local Hispaniolan race, *B. c. antillarum* Riley, as taken from skins by Wetmore and Swales (1931).

DISCUSSION

The humeri of two species, *Columbigallina passerina* and *Phaenicophilus palmarum*, are smaller in Stratum 3 than in Stratum 2. If Bergmann's principle was in operation, this would indicate that the period of deposition of the older Stratum 3 had a warmer climate than the period of pre-Columbian human occupancy of Stratum 2.

Two of the species, *Porzana carolina* and *Seiurus aurocapillus*, are presently winter migrants from North America.

Based on the known habitat preferences of the modern species (Wetmore and Swales, 1931; Bond, 1961), it is possible to form a picture of the surroundings at the time the deposits were laid down. The three rails require fresh water marshes. The zenaida dove, ground dove, gray kingbird, and grassquit are characteristic of open